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Effects of fillers on the properties of liquid silicone rubbers (LSRs)

Liyun Yu, Sindhu Vudayagiri, Shamsul Zakaria, Anne Ladegaard Skov*

The Danish Polymer Centre, Department of Chemical and Biochemical Engineering, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark

**Corresponding author:* Tel.: +45 45252825; Fax: +45 45882258. E-mail: al@kt.dtu.dk

Dielectric electro active polymers (DEAPs) change their shape and size under a high voltage or reversibly generate a high voltage when deformed. To make their performances more efficient, certain properties of the polymers like their dielectric permittivity, electrical breakdown and Young's modulus have to be modified according to the specifications of their respective applications. One such prominent method of modifying the properties is by adding suitable fillers.

Liquid silicone rubbers (LSRs) have relatively low viscosities when compared with thermoplastics, which is favorable for loading of inorganic fillers.

The property improvement of the filled LSRs depends on filler concentration, filler morphology, such as particle size and structure, the degree of dispersion and orientation in the matrix, and also the degree of adhesion with the polymer chains, as well as the properties of the inorganic fillers.

In this study commercially available fillers, such as fumed silica (SiO_2), titanium dioxide (TiO_2), barium titanate ($BaTiO_3$), copper calcium titanate ($CaCu_3Ti_4O_{12}$, CCTO), multi-walled carbon nanotubes (MWCNTs) were added into the LSRs and we examined how the properties of the networks were modified.

The filled elastomers have both favorable properties and shortcomings. The shortcomings are of various types. Fumed silica reinforces the networks with no increase in permittivity ($\varepsilon_{r,SiO2}$ ~ 3.9). Barium titanate possesses high dielectric constant ($\varepsilon_{r,BaTiO3}$ ~ 150) but its heavy density (6.08 g/mL) deteriorates the lightweight advantage of the DEAPs. Micron-sized giant dielectric constant CCTO ($\varepsilon_{r,CCTO}$ ~ 10000) decreases the mechanical performances of the composites. The inhomogeneous compatibility of the unmodified MWCNTs in the silicone system causes the risk of electric conductivity.

Among these additives, the use of multiple titanium dioxides as filler potentially suits to special applications. In the present study, a series of TiO_2 fillers were blended into LSRs, such as hydrophilic/ hydrophobic, micro/ nano scale, anatase/ rutile crystal, sphere/ core-shell structure. The results indicate that the hydrophobic rutile TiO_2 nanofiller is a good candidate for achieving higher permittivity and breakdown strength, as well as favorable elastic modulus of the prepared elastomers.

Keywords: dielectric electro active polymers, liquid silicone rubbers, dielectric permittivity, electrical breakdown, Young's modulus, titanium dioxide